SPS-9 Construction Report
US-54 Near Greensburg, Kansas
Sections 200901 to 200903

SHRP North Central Region

Report Prepared by:

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December 1993

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The SPS-9 Experimental Design and Research Plan

The SPS-9 experiment is entitled "Validation of SHRP Asphalt Specifications nd Mix Design and Innovations in Asphalt Pavements." The SHRP asphalt research is focused on delivering two main products:

- Performance-based asphalt binder specification
- Performance-based asphalt-aggregate mixture specification including the mix design and analysis system

In addition, the SHRP Asphalt Research provides a forum for evaluating innovations in asphalt pavement, such as Stone Matrix Asphalt (SMA) and other materials.

The successful development and refinement of performance-based specifications for asphalt binder and asphalt-aggregate mixtures requires the validation of the binder and mixture properties as important determinants of in-place pavement performance. Also, the evaluation of innovative asphalt pavement materials requires in-service testing under actual traffic and climate conditions.

The SHRP asphalt research program is designed to develop performance-based specifications that address six pavement performance factors: permanent deformation, fatigue cracking, low-temperature cracking, moisture sensitivity, aging, and adhesion. With the results, it is hoped that the requirements for a new or reconstructed asphalt pavement may be defined in terms of the required levels of serviceability in each of these six areas for present and projected traffic loads and environmental conditions.

The SHRP asphalt research program was founded on the premise that asphalt concrete pavement performance is significantly influenced by the properties of the asphalt binder. To design a pavement that provides the performance dictated by its present and future environment, first consideration must be given to selecting an asphalt binder whose properties ensure the required performance levels.

After the influence of the asphalt binder on the performance is defined, the effect of its combination with aggregate must be considered. Some locally-available aggregates may actually detract from the performance-based response of the binder, necessitating a change in aggregate or binder. There is also the possibility that certain aggregates may enhance binder performance, allowing wider latitude in materials selection or pavement thickness.

The mixture specification is viewed as modulating the binder response in each performance area. The availability of both specifications allows a range of materials selection options to be considered for any particular paving project.

The performance-based specification limits and requirements are being developed from an extensive data base related to the types of pavement performance factors that can be defined quantitatively, as measured by accelerated, standardized tests using well-established performance prediction models and validated by correlation with in-place field pavement data.

The objectives of the SPS-9 study are as follows:

- To further validate the performance-based asphalt and asphalt-aggregate mixture specifications through controlled SPS projects;
- To provide for a direct comparison, in terms of measured performance and life-cycle costing analysis, between existing highway agencies' asphalt specifications, asphalt-aggregate mixture specifications, mix design procedures and SHRP's performance-based specifications and mix design and analysis system, stone matrix asphalt (SMA) mixtures, and other innovative features;
- To provide data collected over a long term from controlled field experiments and to provide for step-by-step procedures employing these data for modification of specification requirements at the local, regional or national level.

For the SPS-9 experiment, each test site includes the state's current mix design and the mix developed by SHRP's mixture design and analysis system. Other mixtures may be included along with these two sections. The Kansas SPS-9 project included the Kansas DOT standard mix, the SHRP SUPERPAVE mix, and one SMA mixture. Figure 1 shows the Kansas SPS-9 layout.

Project Details

The Kansas SPS-9 project was constructed in 1993 and is located in the eastbound driving lane of US-54, near Greensburg (see Figure 2 for project location). The project involved the new construction of a two-way bituminous-surfaced roadway, offset from the original alignment by approximately 50 feet. The SPS experiment consisted of three test sections, including one Kansas DOT mixture section, one SUPERPAVE section, and one SMA section, and is built in the dry-freeze zone. Subgrade soils on the project are sandy silt.

The typical sections for the project are shown in Figure 3. Existing topsoil was removed, the underlying materials subcut to accommodate the pavement thicknesses, and the base and surface layers placed in various thicknesses. One and one-half inches of bituminous surface mixture were placed over 9-1/2 inches of bituminous base for the SPS-9 sections. Material was placed and compacted according to standard KDOT specifications section 210.

US-54 carries an average two-way ADT of 5,000, with 28 percent trucks. The estimated design 18K ESAL in the SHRP lane is 469 with a total of 4,690,250 18K ESAL applications over the 10-year design period.

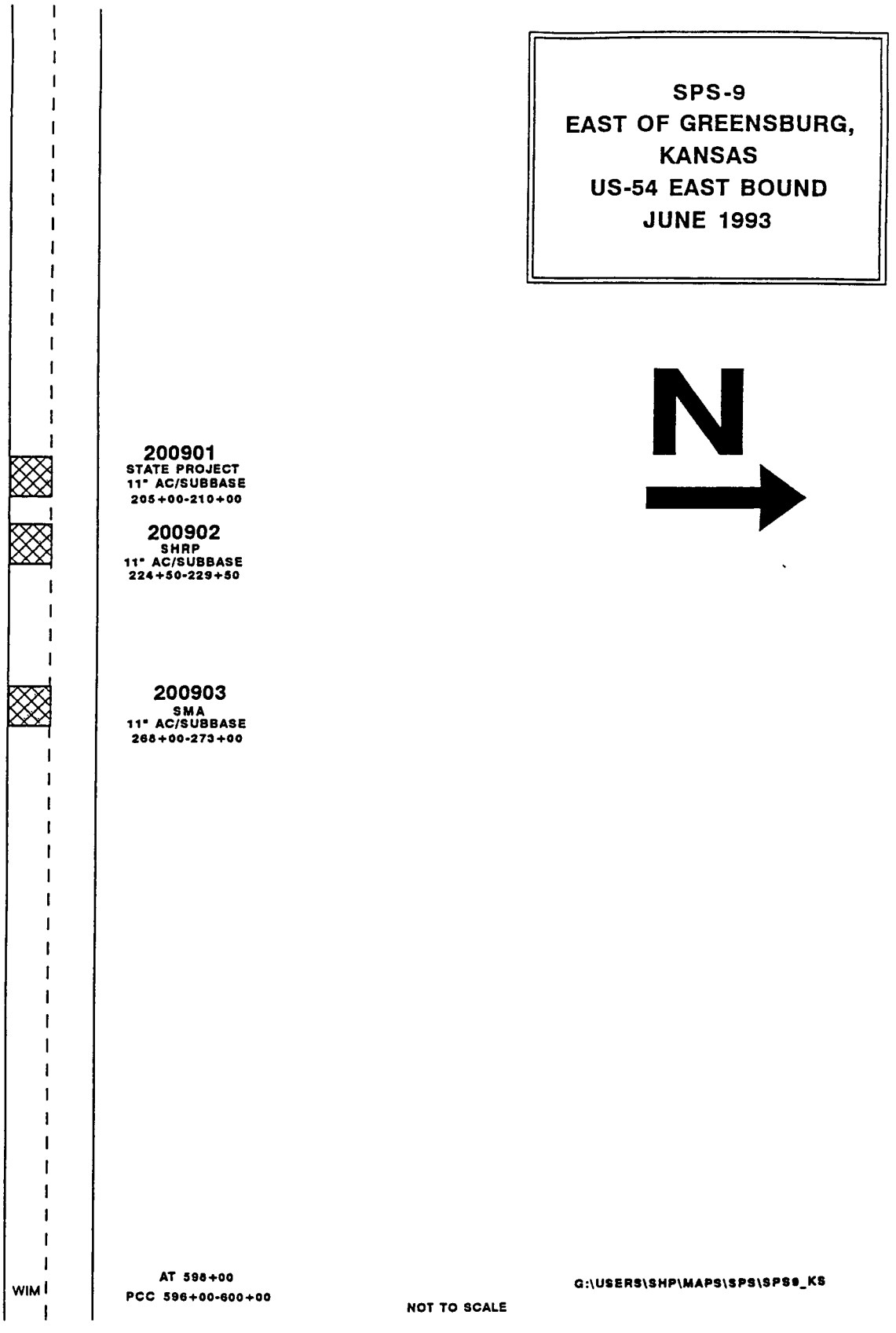

Figure 1. Project Layout

There were no known deviations from project guidelines. All test sections were located between the cities of Greensburg and Haviland. There are no horizontal curves located in the SHRP areas and the vertical grade in the sections varies from -0.05 to +0.62 percent in the direction of travel. All sections are located on fill sections, and none contain underground structures.

No weather station has been installed to date, but one is scheduled for installation in 1994. A weigh-in-motion system was installed and is operating at station 598+00, and was supplied from Saskatoon, Saskatchewan.

Project Coordination

The Kansas DOT conducted the materials sampling and testing, and also provided their own Resident Engineer. Dennis Hermanson served as Construction Engineer and Bob Armstrong, P.E. served as Project Engineer for the DOT. The following people were actively involved in the project:

Kansas Department of Transportation:

Bob Armstrong
Dennis Hermanson
Kansas DOT
P.O. Box 409
Pratt, KS 67124
(316) 672-7494

Paul Gianokon
Jack McClelland
Kansas DOT
500 N. Hendricks
Hutchinson, KS 67501
(913) 663-3361

Bill Parcells
Kansas DOT
2300 Van Buren
Topeka, KS 66611
(913) 296-7410

Lonnie Ingram
Richard Riley
Rodney Maag
Kansas DOT
Docking State Office Bldg.
Topeka, KS 66612
(913) 296-3711

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Gene Skok
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1983 Sloan Place - Suite 10
St. Paul, MN 55117
(612) 776-7522

Richard Ingberg
FHWA
1983 Sloan Place - Suite 10
St. Paul, MN 55117
(612) 776-2210

The general contractor for this project was:

Popejoy Construction Co., Inc.
Box 385
Ulysses, KS 67880
Phone: (316) 356-3404

Venture Corporation was subcontracted to perform all of the work required for the construction of the SPS-9 project, including grading and paving.

Layout

Figure 1 shows the section layout, and Table 1 gives a description of the sections.

Table 1. Kansas SPS-9 Section Layout

Construction Station	SHRP ID	Base	Surface Thickness (Design)
205+00 to 210+00	200901	9" Bituminous Base Course	1.5"
224+50 to 229+50	200902	9" Bituminous Base Course	1.5"
268+00 to 273+00	200903	9" Bituminous Base Course	1.5"

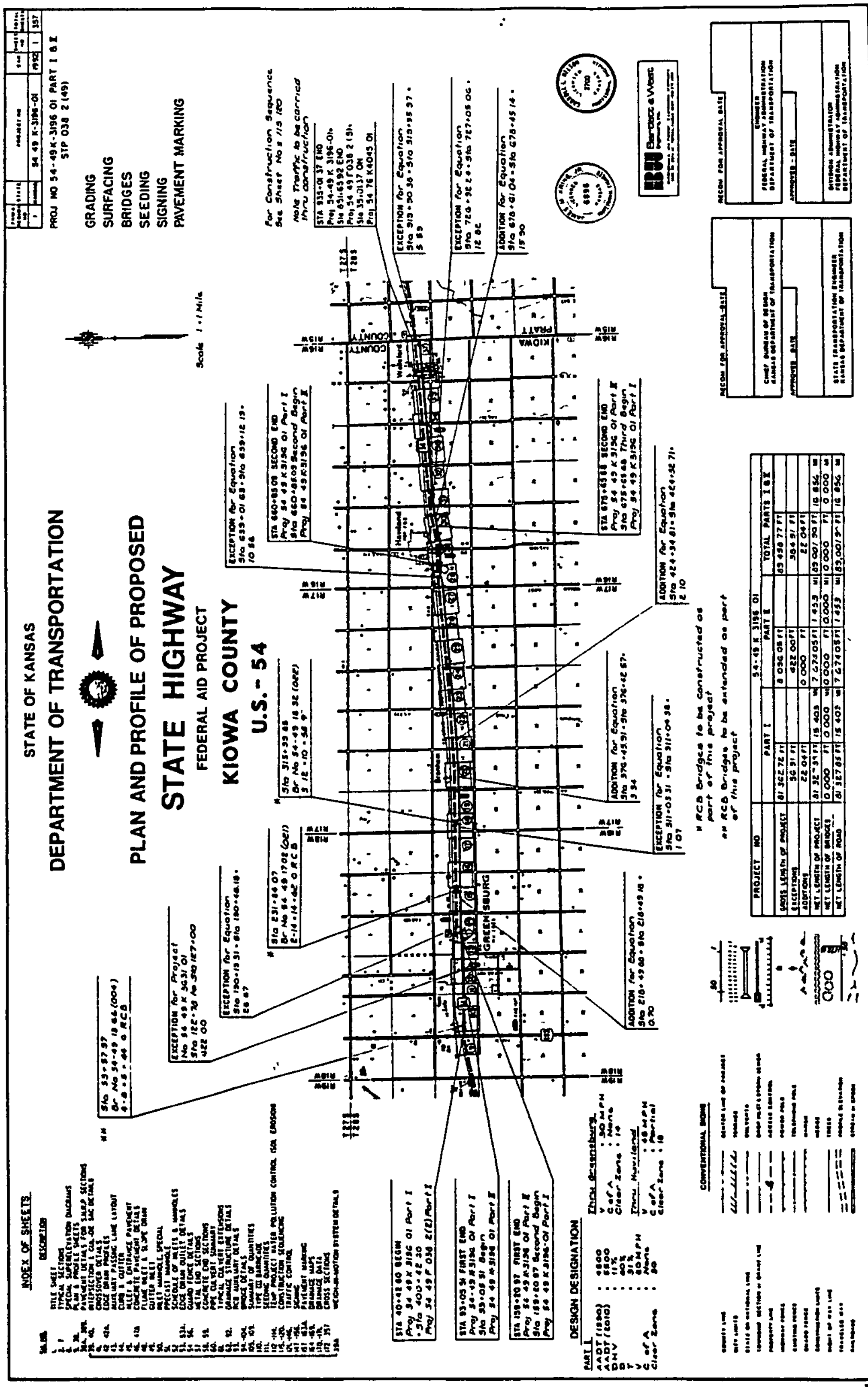


Figure 2. Project Location

Material Sampling and Testing

The Material Sampling and Testing Plan is shown in Figure 4. KDOT personnel conducted all sampling and testing and data collection, with assistance from the LTPP North Central Regional Office. Table 2 gives a listing of all samples taken for the project.

Table 2. Bulk Material Sampling During Construction

Material and Sample Description	Number of Samples	Sample Location
Asphalt Concrete Coring - 4" Diam. Cores Bulk Sampling (100 lbs of each mix, uncompacted)	 21 3	 Regional Contractor Lab Minneapolis, MN
Asphalt Cement 5 gallons each sample	3	Regional Contractor Lab Minneapolis, MN
Materials Shipped to SHRP Asphalt Reference Library		
Asphalt Cement 5 gallon containers	6	SHRP Reference Library Reno, NV
Aggregate 55 gallon drums	4	SHRP Reference Library Reno, NV
Finished Asphaltic Concrete Mix 5 gallon containers	12	SHRP Reference Library Reno, NV

Construction

Construction of the project began in the Fall of 1992, with all required removals and utility relocations. Work on the base and subbase preparation was scheduled to begin May 1, 1993, but was delayed due to rain. Work did begin in late May, but was slow.

The contractor experienced several problems during construction, many of which were caused by the weather. The area experienced much higher than average precipitation during the spring of 1993, resulting in delays and a wet subgrade. To dry out the subgrade, the contractor was allowed to incorporate flyash.

During the FWD testing, high deflections were measured in the base in some areas. These deflections will continue to be monitored.

All work was completed on the test sections, and the roadway opened to traffic on November 1, 1993.

Subgrade Preparation

Because of the heavy rains, the contractor was allowed to incorporate flyash into the subgrade to create a stable working platform. This material was mixed into the upper 7 in. of soil, and is a Type C flyash. The target application rate was 8 percent. According to the Kansas DOT personnel on site, the contractor had problems incorporating the water into the flyash/subgrade mixture. They changed procedures to incorporate the water at the front of the mixing drum. This procedure worked much better. Water was added to increase the moisture content approximately 13.5 percent, although the DOT estimated the target moisture content to be about 17 percent. After the incorporation of the water, a Cat vibratory compactor was used to the compact the flyash/subgrade mixture.

In areas where the subgrade is comprised of up to 3 feet of fill and natural subgrade, two layers were sampled as part of the sampling and testing plan (subbase and subgrade).

Mix Designs and Paving

The SHRP mix designs for base and surface are given in Figure 5. The KDOT asphalt material did not meet the SHRP specification, and was modified. An AC 64-34 or 70-34 was specified in the mix design. Construction of the SUPERPAVE and SMA mixtures went well, with no compaction problems. The SUPERPAVE mix was placed September 28, 1993 and the SMA section paved on October 19th.

Table 3. Construction Schedule

SPS: 9					**Agency: Kansas**
Test Section		**Construction**		**Range of Thicknesses**	**MST Completed**
Layer	**Designation**	**Start**	**Complete**		
1	Base Course	9/24/93	10/18/93	9 inches	10/31/93
2	Surface Course	10/19/93	10/29/93	1.5 inches	10/31/93

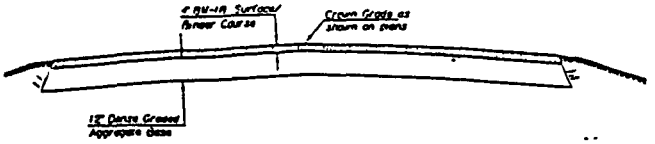
Dates:
Opened to Traffic: November 1993
WIM Installed: October 1993
WIM Operational: October 1993
Weather Station Installed: Not to date
Weather Station Operational: No

Significant Factors Which May Affect Performance of Section

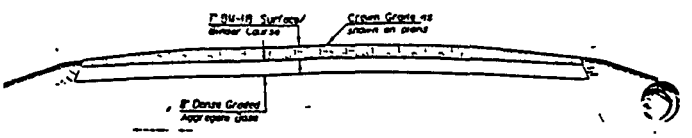
Environmental
Heavy rains delayed construction and resulted in wet subgrade. To dry out the subgrade, the construction was allowed to incorporate 8% Type C flyash.

Construction
None

SHRP 2 115.2-115.3 4.5*



SHRP 1 114.9-115.0 13*



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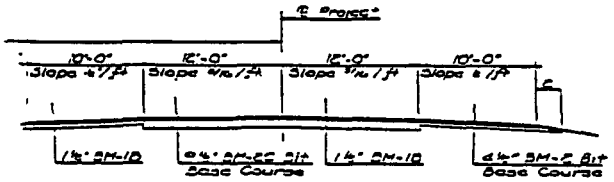

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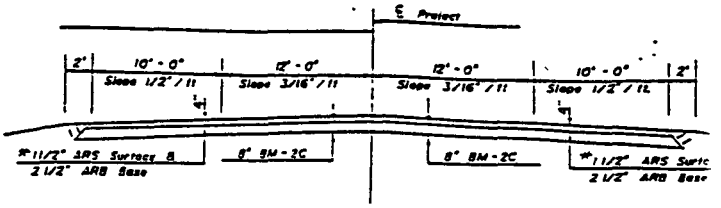

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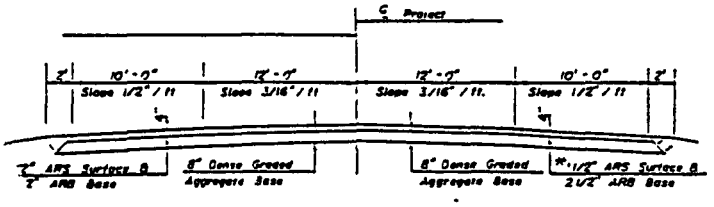

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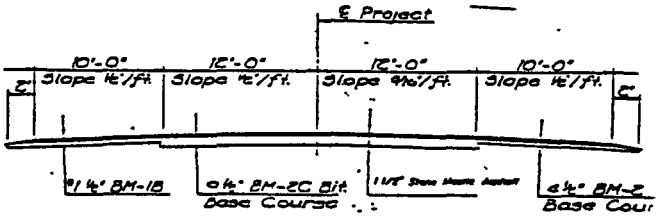

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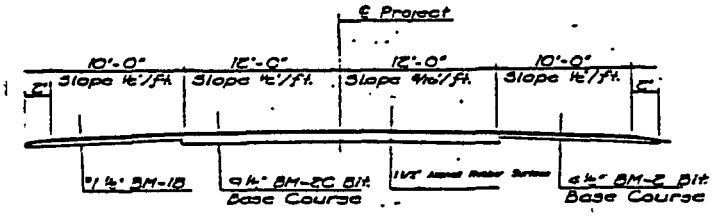
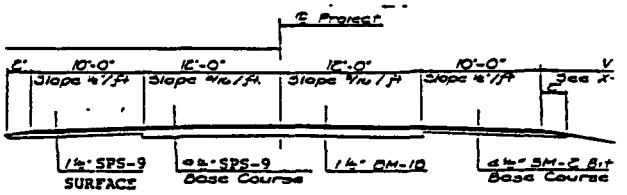
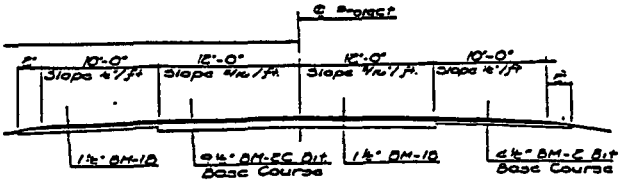


SPS-9 SUPERPAVE 109.3-109.5



SPS-9 CONTROL 109.0-109.1



* - Design Life of Asphalt

Figure 3. Typical Sections

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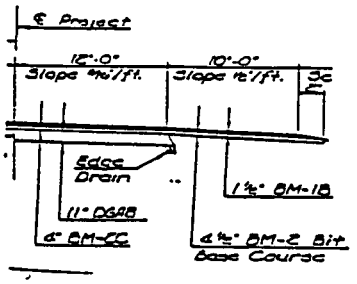

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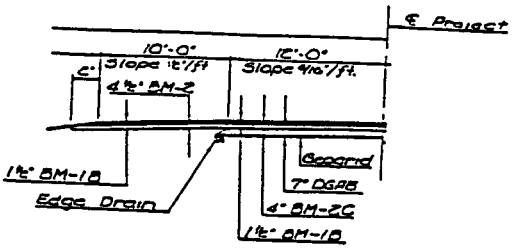
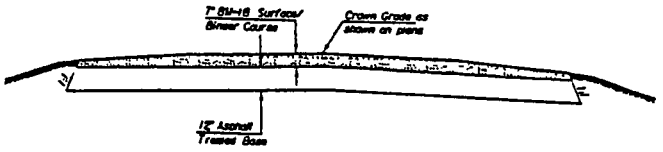
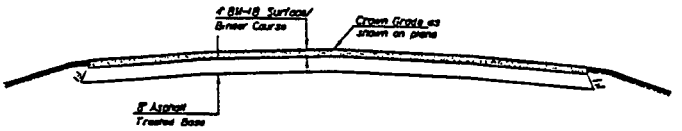


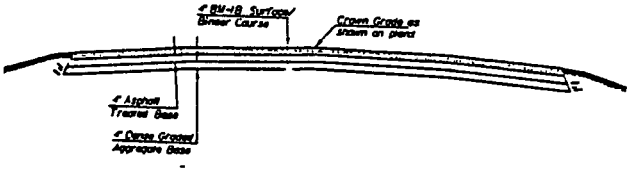
SHRP 12 117.1-117.2 47*



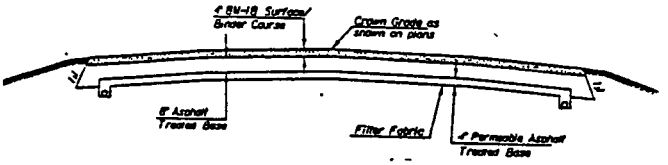
SHRP 11 117.0-117.1 28*



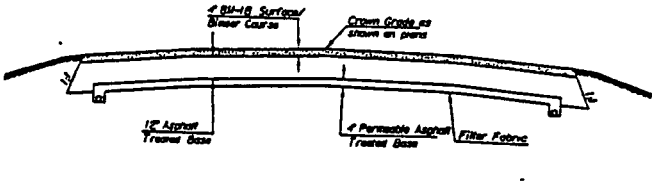
SHRP 10 116.8- 116.9 2*



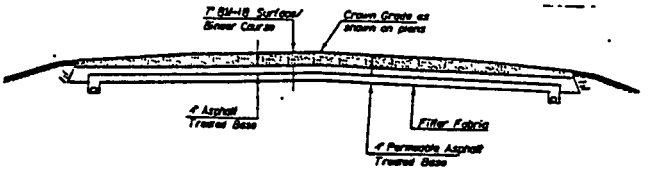
SHRP 9 116.3-116.4 39*



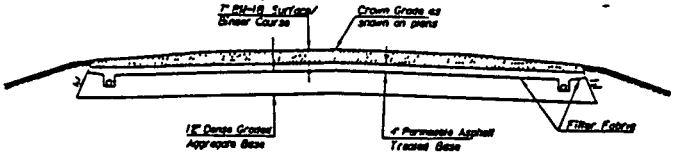
SHRP 8 116.2-116.3 95*



SHRP 7 116.1-116.2 36*



SHRP 6 116.0-116.1 120*



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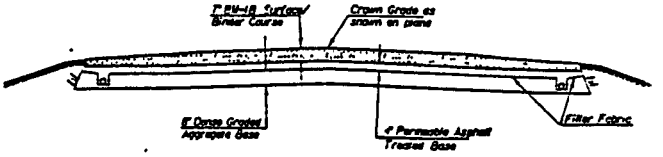
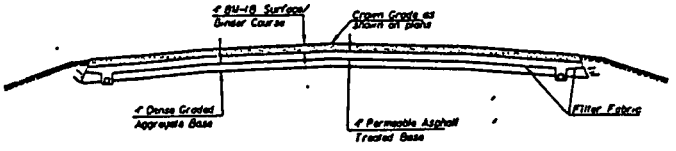


SHRP 4 115.7-115.8 6.5*



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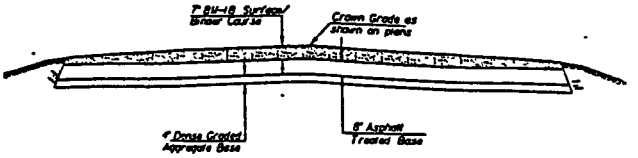

* - Design Life of Asphalt

Figure 3. Typical Sections (continued)

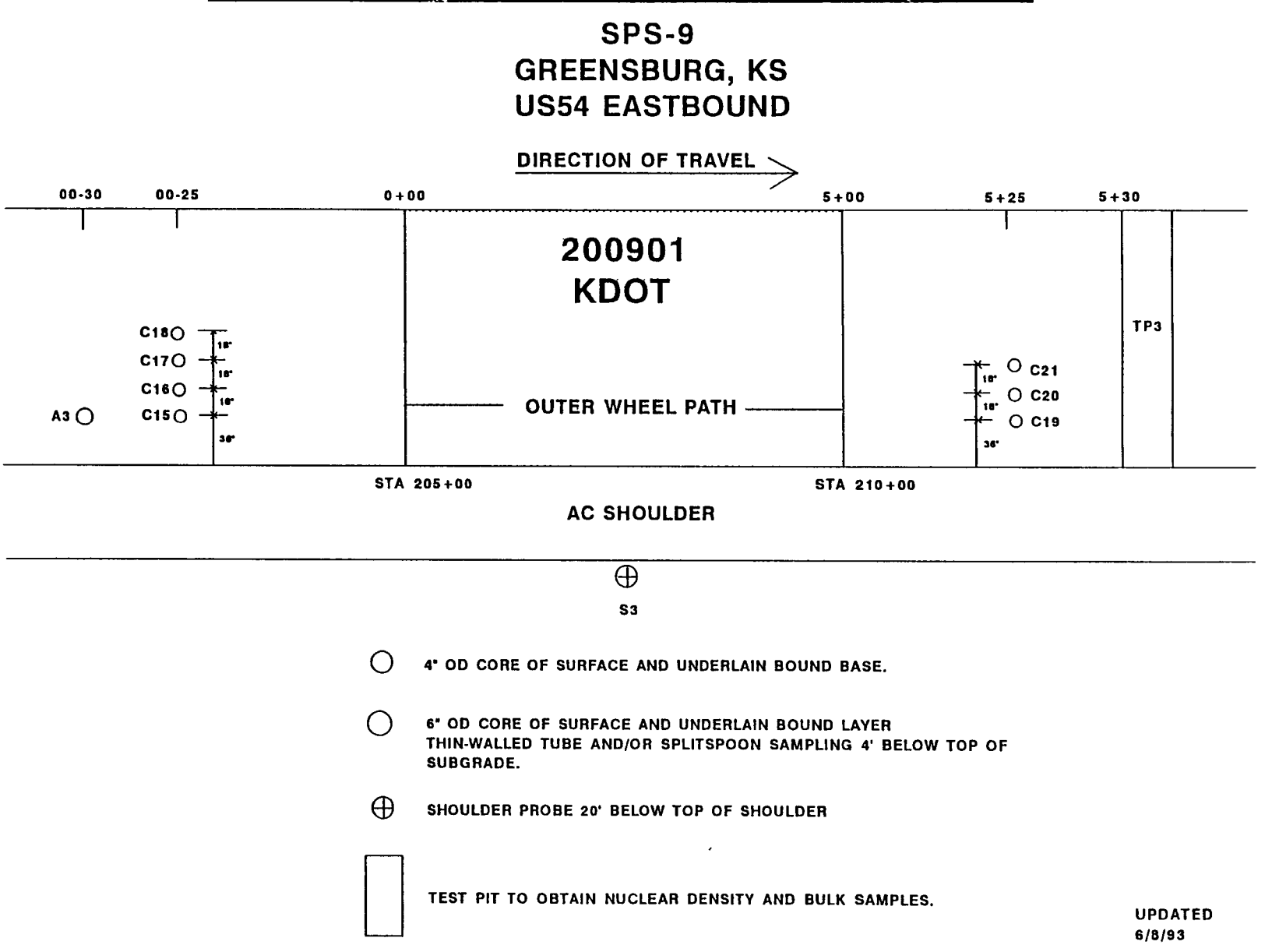

Figure 4. Material Sampling and Testing Plan

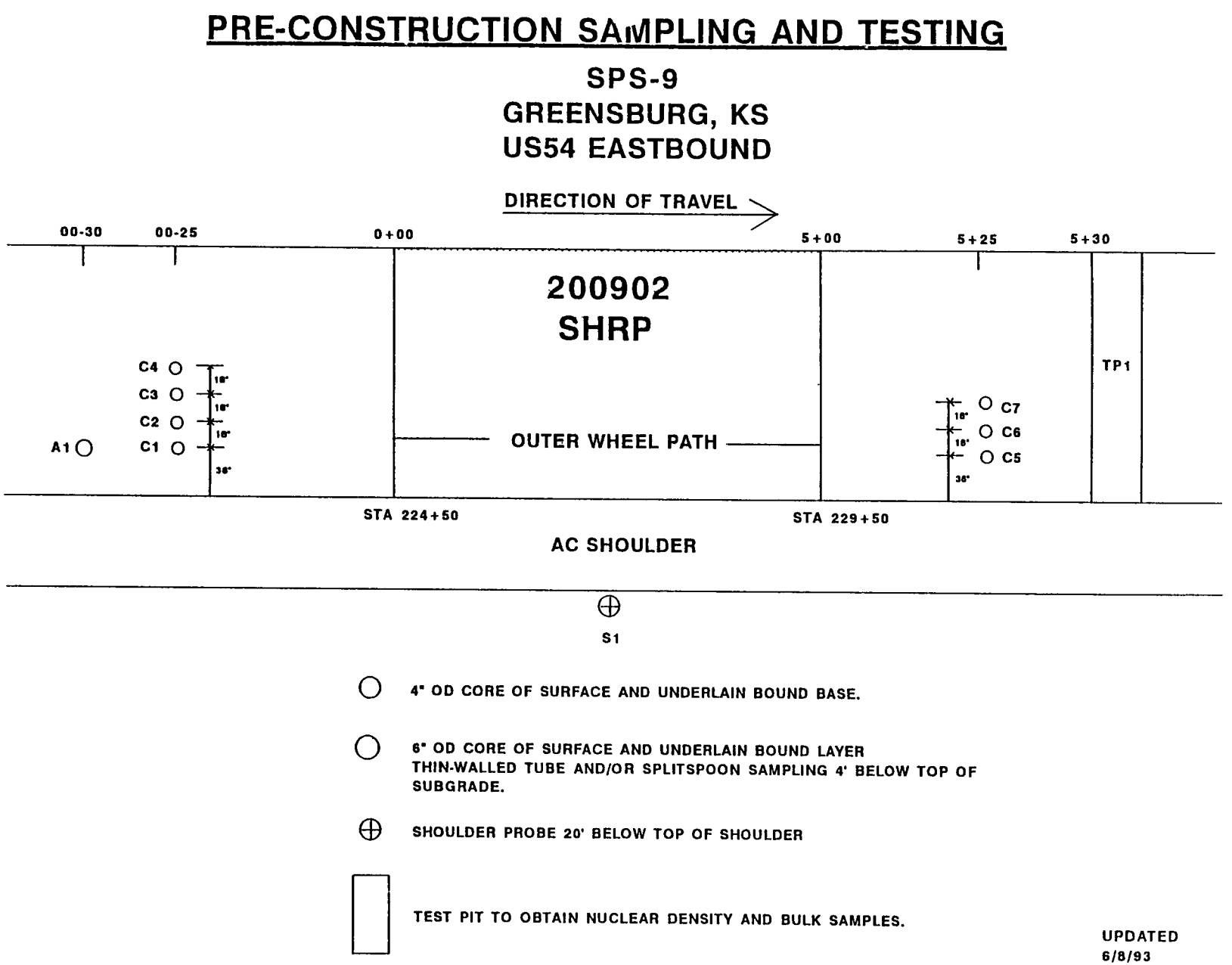

Figure 4. Material Sampling and Testing Plan (continued)

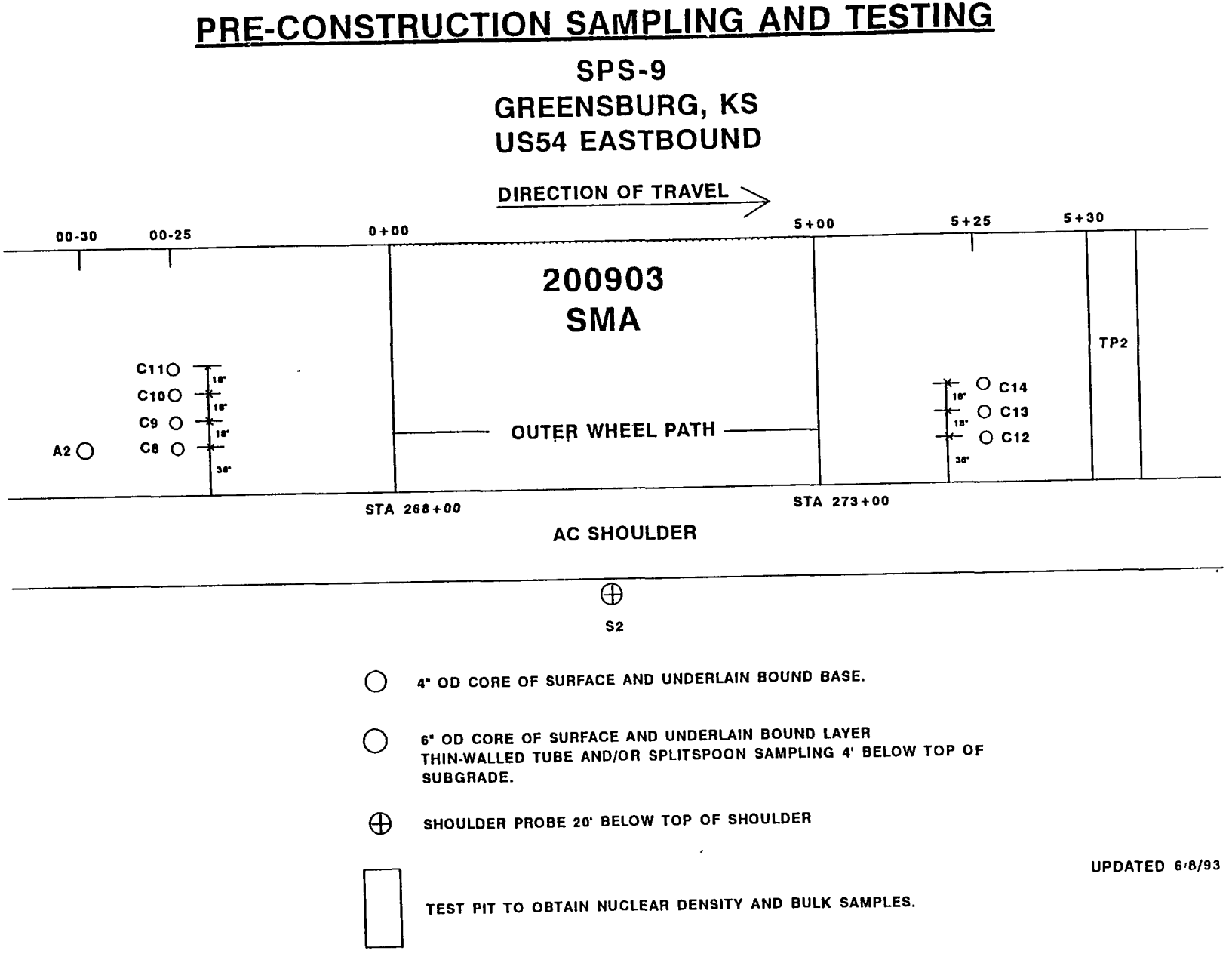

Figure 4. Material Sampling and Testing Plan (continued)

KANSAS DEPARTMENT OF TRANSPORTATION
MARSHALL TEST RESULTS Taken for SHRP Superpave Surface Design SPS-9

Project 54-49-K3196-01 County KIOWA Lab. No. _____

Field Engineer BOB ARMSTRONG Contractor POPE-CV. VENTURE

Specification SPS-9 SHRP Hot Mix Producer VENTURE

Asphalt Source Koch Date Received _____

Asphalt Grade 64-34 or 70-34 Date Reported 9/16/93 Asphalt Institute

Mix Designation SPS-9 Surface Filler Binder Ratio 0.7 Film Thickness _____

	Percent Retained – Square Mesh Sieves										
	1"	3/4"	1/2"	3/8"	4	8	16	30	50	100	200
Job Mix Spec. Band		0	0 10	7 19	46 56	67 77	77 85	84 90	89 95	92 98	94 98
Job Mix Single Point		0	4	13	51	72	81	87	92	95	96
~~Marshall Gradation~~ Tolerance					±5	±5	±4	±3	±3	±3	±2

(Use Spec. tolerance as Bill-13)

Test Data					
Range Tested (% AC)	Increment (% AC)	Marshall Mixing Temperature Range (°F)		Marshall Compaction Temperature (°F)	
to		Spec.	318 to 330	295 to 305	*
		Actual	325 to	300 to	

*Range for Field Compaction of Marshall Specimens.
Operating Range for Hot Mix Plant 295 °F to 330 °F

Evaluation of Test Results	♦ Recommend
Asphalt Content %	5.3 *
Air Voids (3 to 5%)	4.0
VFA (≥ 70%)	73.0
Bearing Capicity (150-300 psi)	
Density (Peak ± 0.5%)	145.6
Stability	
V.M.A.	14.7
Max. Sp. Gr.	2.434
Theor. Max Density (P.C.F.)	151.98

eld Engineer
Jistrict Engineer
Bureau of Construction & Maintenance
Bureau of Materials & Research (2)
Materials & Research Center
Producer
File

♦ Values at Recommended Asphalt Content
P_b Max.= _____

* DRY WT. – ASPHALT INSTITUTE SHOWS 5.5% WET WEIGHT

_____
District Materials Engineer

Figure 5. Mix Design

KANSAS DEPARTMENT OF TRANSPORTATION
DESIGN JOB-MIX GRADATION COMPUTATION SHEETS

(Sheet 1)

Project 54-49-K3196-01 Co. Kiowa Mix Desig. SPS-9 SURFACE Lab. No. ASPH. INSTITUTE (SURFACE)

1. Aggregate : BLEND No. 4 ASPHALT INSTITUTE

Type	Producer or Pit Name	Legal Description & Official Quality	County
CS-1D	Sedan Limestone	NE¼, S10, T28S, R11E	Greenwood
CS-2D	Clayton Stone	SW¼, S7, T26N, R26E	Union, NM
CS-1K	Martin Marietta	SW¼, S6, T31S, R11E	Elk
SSG-3	Hammand Sand	SW¼, S17, T29, R17	Kiowa

2. Approximate Individual Aggregate Gradation

% Passing
% Retained

Type	% Mix	1"	3/4"	1/2"	3/8"	4	8	16	30	50	100	200	P.I.
CS-1D	15		100 0	76 24	45 55	4 96	3 97	3 97	3 97	3 97	3 97	2 98	
CS-2D	20				100 0	91 9	59 41	37 63	25 75	18 82	13 87	10 90	
CS-1K	45			100 0	97 9	28 72	3 97	2 98	2 98	2 98	2 98	2 98	
SSG-3	20		100 0	98 2	97 3	88 12	74 26	53 47	35 65	13 87	5 95	2 98	

3. Computation of Single Point Grading

Type	% Mix	1"	3/4"	1/2"	3/8"	4	8	16	30	50	100	200	P.I.
CS-1D	15		0	3.6	8.2	14.4	14.6	14.6	14.6	14.6	14.6	14.7	
CS-2D	20				0	1.8	8.2	12.6	15.0	16.4	17.4	18.0	
CS-1K	45			0	4.1	32.4	43.7	44.1	44.1	44.1	44.1	44.1	
SSG-3	20		0	0.4	0.6	2.4	5.2	9.4	13.0	17.4	19.0	19.6	
Subtotal			0	4	12.9	51.0	71.7	80.7	86.7	92.5	96.1	96.4	
Single Point			0	4	13	51	72	81	87	92	95	96	

4. Design Job-Mix Grading

Type	Limit	1"	3/4"	1/2"	3/8"	4	8	16	30	50	100	200
Single Point			0	4	13	51	72	81	87	92	95	96
Same as BM-2 Tolerance (±)						5	5	4	3	3	3	2
SPS-9 BM- Surface	Lower		0	0	7	46	67	77	84	89	92	94
	Upper		0	10	19	56	77	85	90	95	98	98

5. Master Gradation Limits

Mix Type	Limit	1"	3/4"	1/2"	3/8"	4	8	16	30	50	100	200
BM-	Lower											
	Upper											

Figure 5. Mix Design (continued)

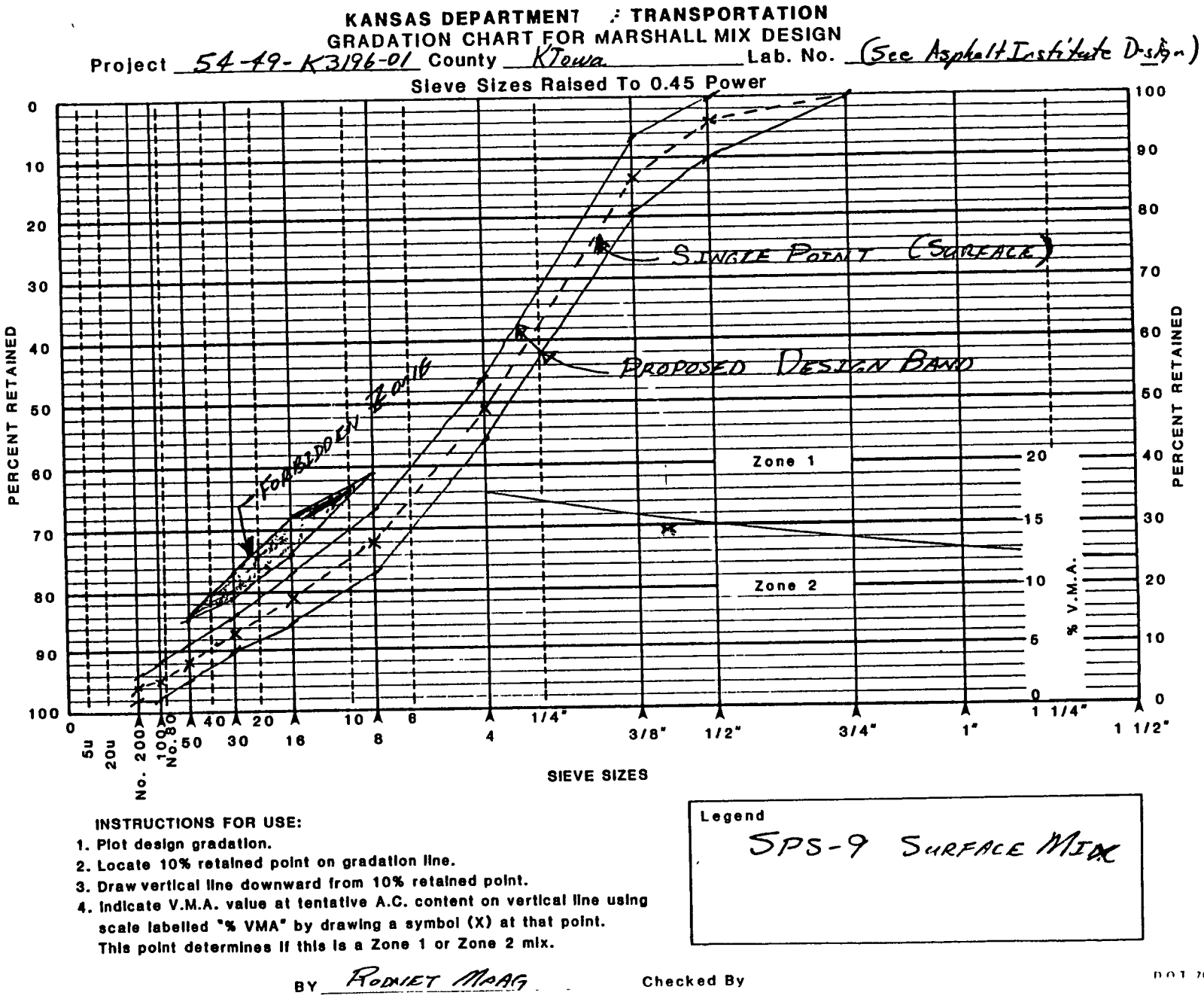

Figure 5. Mix Design (continued)

KANSAS DEPARTMENT OF TRANSPORTATION
MARSHALL TEST RESULTS

Taken for SHRP Superpave Base Design SPS-9

roject 54-49-K3196-01 County Kiowa Lab. No.

Field Engineer Bob Armstrong Contractor Popejoy - Venture

Specification SPS-9 SHRP Hot Mix Producer Venture

Asphalt Source Koch Date Received

Asphalt Grade 64-34 or 70-34 Date Reported 9/2/93 Asphalt Institute

Mix Designation SPS-9 Base Filler Binder Ratio 0.7 Film Thickness

	Percent Retained - Square Mesh Sieves										
1.5"	1"	3/4"	1/2"	3/8"	4	8	16	30	50	100	200
Job Mix Spec. Band 0	0	0	11	28	53	70	79	84	89	91	94
	3	10	31	42	65	82	89	94	97	99	98
Job Mix Single Point 0	0	7	21	34	59	76	84	89	93	95	96
~~Marshall Gradation~~ Tolerance				±6	±6	±6	±5	±5	±4	±4	±2

(Use same tolerance as BM-2C)

Test Data				
Range Tested (% AC)	Increment (% AC)	Marshall Mixing Temperature Range (°F)		Marshall Compaction Temperature (°F)
to		Spec.	318 to 330	295 to 305 *
		Actual	325 to	300 to

*Range for Field Compaction of Marshall Specimens.
Operating Range for Hot Mix Plant 295 °F to 330 °F

Evaluation of Test Results	* Recommend
Asphalt Content %	6.0 *
Air Voids (3 to %)	4.3
VFA (≥ 70%)	72
Bearing Capicity (150-300 psi)	
Density (Peak ± 0.5%)	149.95
Stability	
V.M.A.	14.9
Max. Sp. Gr.	2.507
Theor. Max Density (P.C.F.)	156.44

ield Engineer
District Engineer
Bureau of Construction & Maintenance
Bureau of Materials & Research (2)
Materials & Research Center
Producer
File

* Values at Recommended Asphalt Content
P_b Max.=
* Dry Wt. - Asphalt Emulsion shall be 57% Wet weight

District Materials Engineer

D.O.T. Form 701

Figure 5. Mix Design (continued)

KANSAS DEPARTMENT OF TRANSPORTATION
DESIGN JOB-MIX GRADATION COMPUTATION SHEETS

Project 54-49-K3196-01 Co. KIOWA Mix Desig. SPS-9 Base Lab. No. Asphalt Institute (Base) (Sheet 1)

1. Aggregate : BLEND No. 5 ASPHALT INSTITUTE

Type	Producer or Pit Name	Legal Description & Official Quality	County
CS-1B	Clayton Stone	SW¼, S7, T26N, R3E	Union, NM
CS-1K	Martin Marietta	SW¼, S6, T31S, R11E	ELK
CS-2D	Clayton Stone	SW¼, S7, T26N, R3E	Union, NM
SSG-2	Secat Pit Run	E½, S4, T29W, R17W	Kiowa

2. Approximate Individual Aggregate Gradation (% Passing / % Retained)

Type	% Mix	1"	3/4"	1/2"	3/8"	4	8	16	30	50	100	200	P.I.
CS-1B	32	100 / 0	80 / 20	35 / 65	5 / 95	2 / 98	2 / 98	2 / 98	2 / 98	2 / 98	2 / 98	2 / 98	
CS-1K	33			100 / 0	91 / 9	28 / 72	3 / 97	2 / 98	2 / 98	2 / 98	2 / 98	2 / 98	
CS-2D	25				100 / 0	91 / 9	59 / 41	37 / 63	25 / 75	18 / 82	13 / 87	10 / 90	
SSG-2	10	100 / 0	98 / 2	96 / 4	93 / 7	87 / 13	74 / 26	58 / 42	37 / 63	13 / 87	5 / 95	3 / 97	

3. Computation of Single Point Grading

Type	% Mix	1"	3/4"	1/2"	3/8"	4	8	16	30	50	100	200	P.I.
CS-1B	32	0	6.4	20.8	30.4	31.4	31.4	31.4	31.4	31.4	31.4	31.4	
CS-1K	33			0	3.0	23.8	32.0	32.3	32.3	32.3	32.3	32.3	
CS-2D	25				0	2.2	10.2	15.8	18.8	20.5	21.8	22.5	
SSG-2	10	0	0.2	0.4	0.7	1.3	2.6	4.2	6.3	8.7	9.5	9.7	
Subtotal		0	6.6	21.2	34.1	58.7	76.2	83.7	88.8	92.9	95.0	95.9	
Single Point		0	7	21	34	59	76	84	89	93	95	96	

4. Design Job-Mix Grading

Type	Limit	1"	3/4"	1/2"	3/8"	4	8	16	30	50	100	200
Single Point		100 / 0	93.4 / 7	78.8 / 21	65.9 / 34	41.3 / 59	23.8 / 76	16.4 / 84	11.3 / 89	7.1 / 93	5.1 / 95	4.1 / 96
Same as BM- 2C Tolerance (±)		—	—	—	6	6	6	5	5	4	4	2
SPS-9 ~~BM~~ Base	Lower	0	0	11	28	53	70	79	84	89	91	94
	Upper	3	10	31	42	65	82	99	94	97	99	98

5. Master Gradation Limits

Mix Type	Limit	1"	3/4"	1/2"	3/8"	4	8	16	30	50	100	200
~~BM~~	Lower											
	Upper											

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Figure 5. Mix Design (continued)

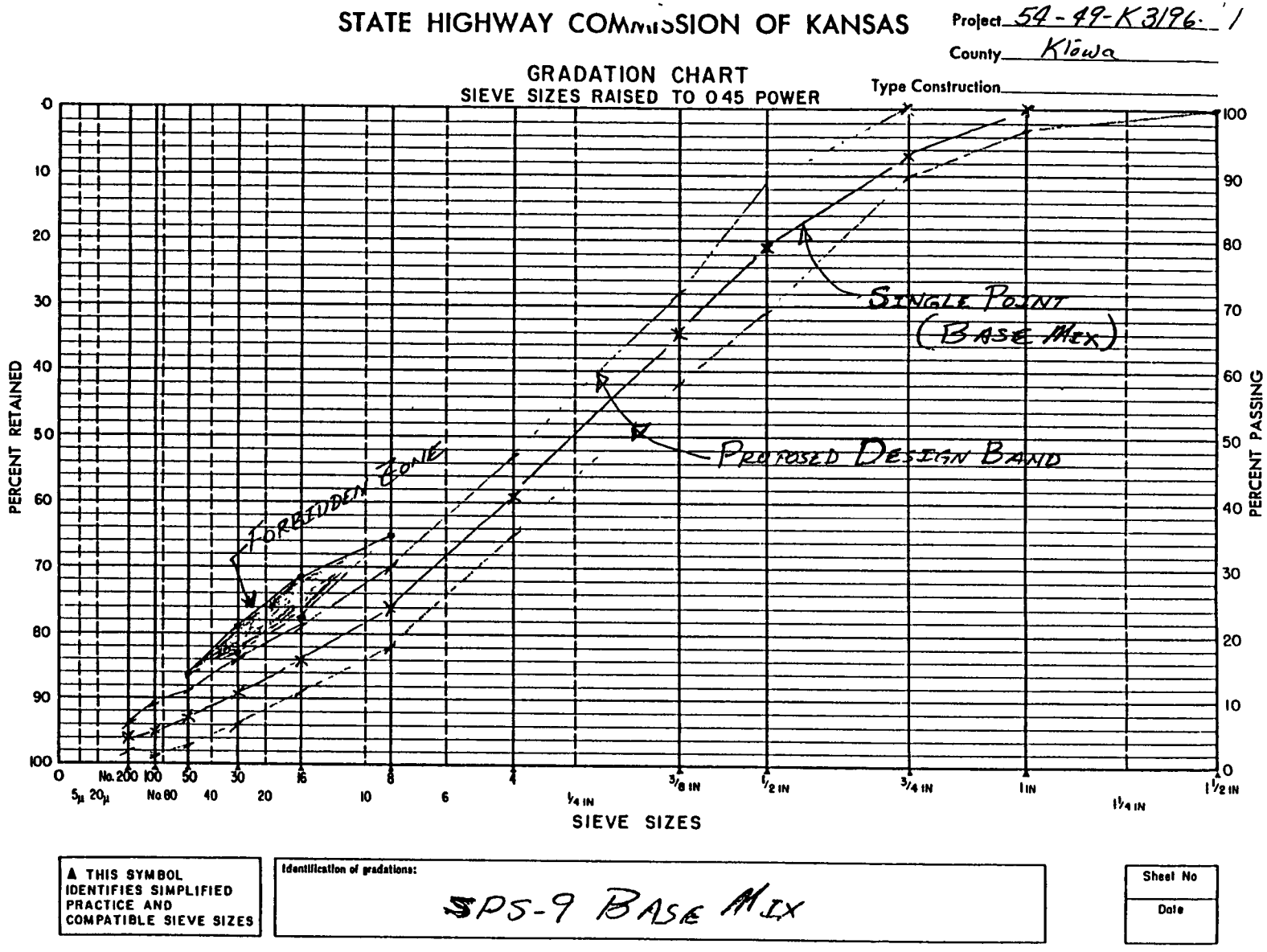
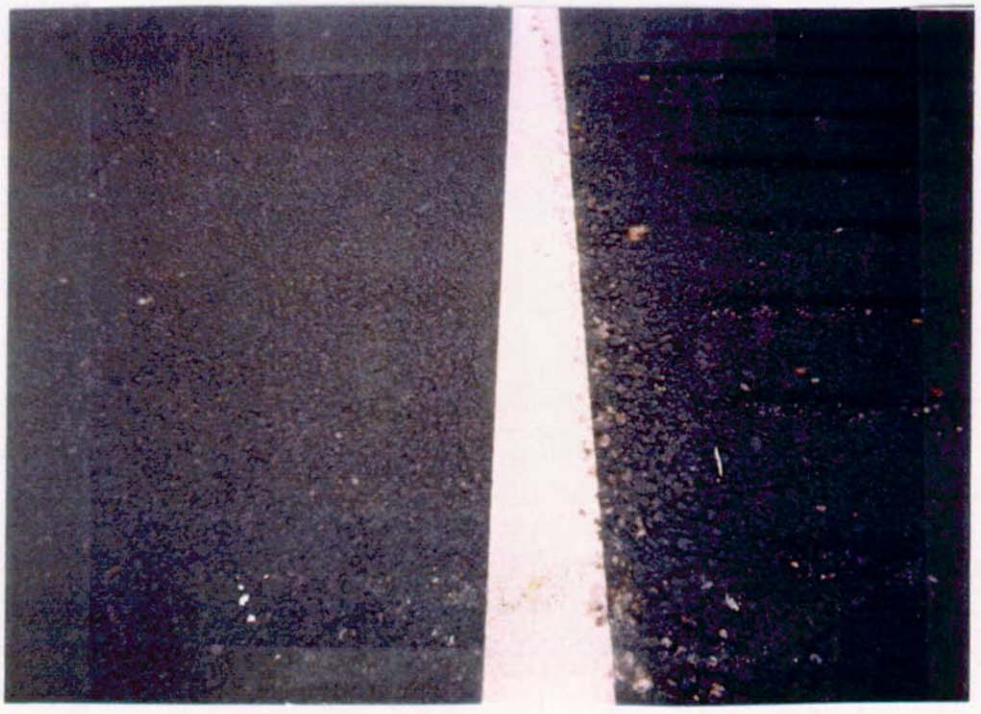


Figure 5. Mix Design (continued)

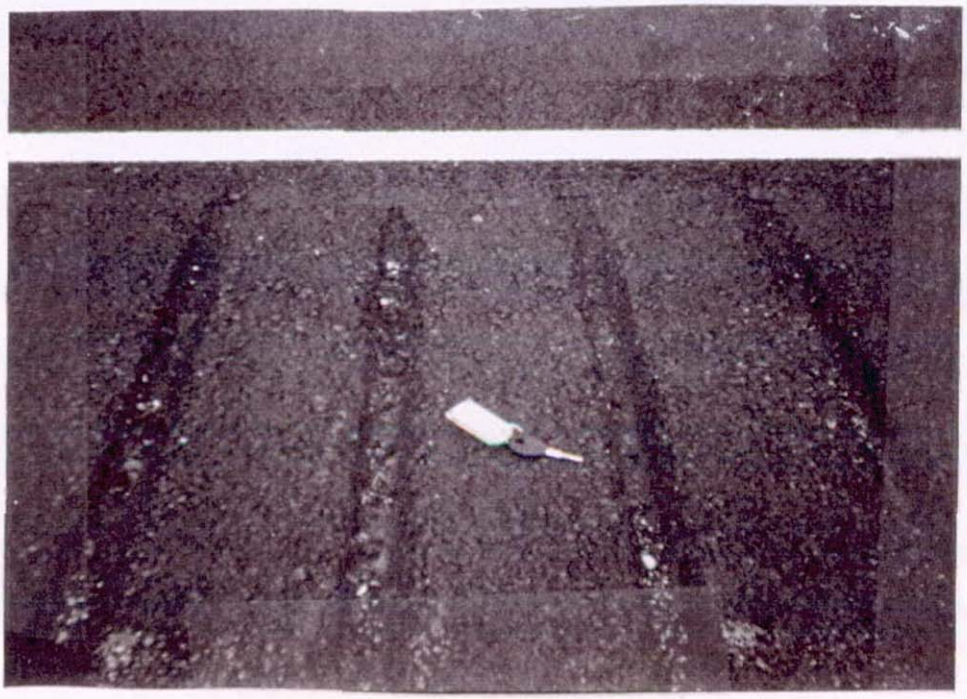
SUPERPAVE Section 200902



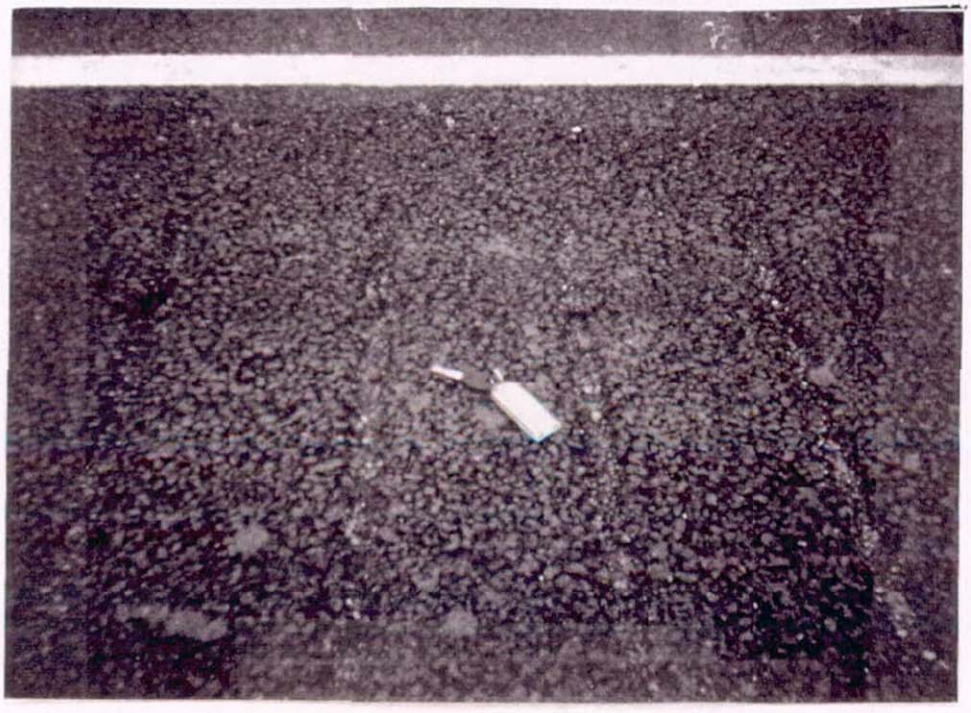
SUPERPAVE Section Interface
Left SUPERPAVE Right KDOT Mixture

SMA Section 200903

SMA Section 200903



KDOT Mixture Section 200901



SMA Section 200903